ASTR 1020: Stars & Galaxies

October 21, 2013

- Reading: Chapter 19, Sections 19.1-19.2 (for Friday).
- Exam 2 on Wednesday.
- Review Session on Tuesday night at 7 pm, EDUC 155.

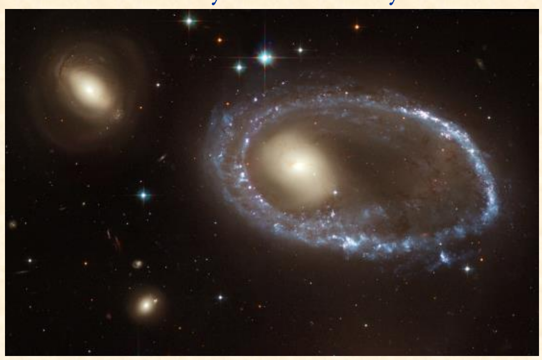
Exam 2 will cover

- All material discussed since Exam 1 in class, readings, recitations, and homeworks up through today's class.
- Textbook: Chapters 6, 15, 16, 17, 18.
- *MasteringAstronomy* Homeworks on *The Properties of Stars, Star Birth, and, The Lives of Stars*.

The Day of the Exam

- Bring a #2 pencil and eraser or pen.
- One sheet of paper with your notes and study hints.
- Bring a calculator if you think you'll need one.
- Please be prepared to get started right away at 1 pm.

Astronomy Picture of the Day



The sparkling blue ring, around the yellowish nucleus of what was once a normal spiral galaxy, is 150,000 light-years in diameter, making it larger than the Milky Way. The galaxy is a member of the class of so-called *ring galaxies*. It lies 300 million light-years away in the direction of the southern constellation Dorado.

The Stellar Graveyard

Low mass stars → white dwarfs
gravity vs. electron degeneracy pressure

High mass stars → neutron stars
Gravity vs. neutron degeneracy pressure

Even more massive cores → black holes
Gravity wins…..

Reading Clicker Question: How do we know pulsars are neutron stars?

A. The X-ray intensity is too strong to come from a white dwarf.
B. Pulsars spin too fast to be as large as a white dwarf.
C. The observed size of the accretion disk is too small to be a white dwarf.
D. The radiation shows a gravitational redshift that requires a mass greater than the white dwarf limit.

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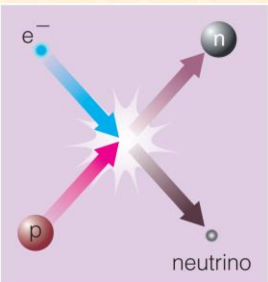
Today: Neutron Stars

- Gravity vs. Neutron degeneracy pressure
- Size ~ 10 km !!

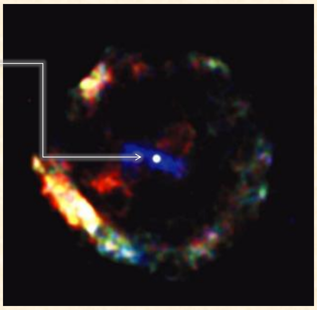
=>Crushing gravity at its surface.

Neutron star over New York City



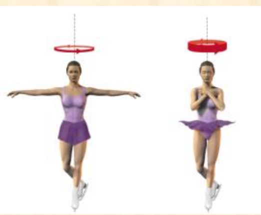
- Electron degeneracy pressure goes away because electrons combine with protons, making neutrons and neutrinos.
- Neutrons collapse to the center, forming a ***neutron star.***

- Supernova remnant (386 AD) and pulsar, seen in X-ray light
- A neutron star is the ball of neutrons left behind by a massive-star supernova.
- Degeneracy pressure of neutrons supports a neutron star against gravity.



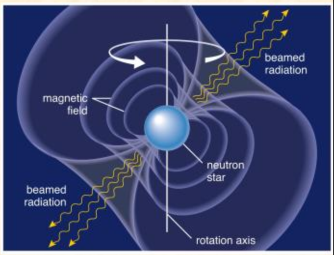
Pulsars

- Collapse to a neutron stars increases both rotation and magnetic field
- Newly collapsed neutron stars rotate 100s to 1000s of times per second

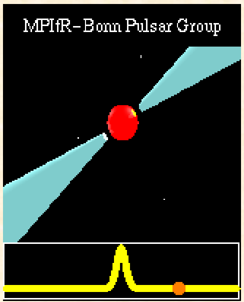


Conservation of Angular Momentum

- A ***pulsar*** is a neutron star that beams radiation along a magnetic axis that is not aligned with the rotation axis.
- Magnetic fields focus energy/radiation along magnetic poles
- New form of light = synchrotron radiation

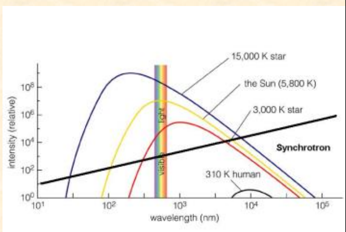


When the “beam” sweeps across the Earth, we see a pulsar



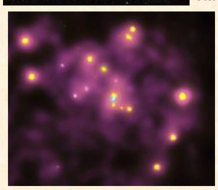
Synchrotron Radiation

- Fast electrons in strong magnetic fields → neutron stars, black holes.
- Different shape from thermal radiation: strongest emission in radio & X-ray.



Not matched scales!

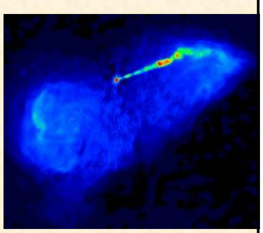
Normal stars



Neutron stars, black holes

- Really stands out in radio and X-ray where there is little thermal radiation
- Visible light versus X-rays show stars versus “collapsed objects”

Visible light vs. Radio Thermal versus Synchrotron



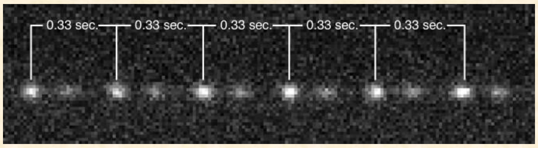
Observing Pulsars

- Jocelyn Bell: Cambridge graduate student in 1967 discovered pulsars by accident from an early radio telescope

- LGM’s?

Pulsar “Lighthouses” don’t actually pulse

- Must be very compact object to spin so fast
- Spin slows down gradually (thousands of years)



Clicker Question

Could there be neutron stars that appear as pulsars to other civilizations but not to us?

A. Yes
B. No

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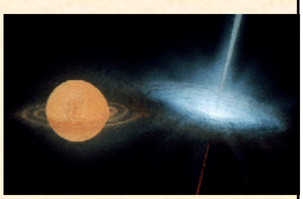
Neutron Stars in Binary Systems

- Mass transfer: Gravitational potential energy
  → X-ray radiation emission
- X-Ray Binary system, X-ray bursters
- Matter falling through the spinning disk can spin UP the pulsar!



When the mass is too great….

- For even neutron degeneracy to hold up, supernova core collapses to an infinitely small point
- → Black Hole: Fiske Planetarium show on “Dr. Einstein’s Universe” described this.